Space Weather Technical Forecast

Issued on Tuesday, 27 December 2022 at 01:28 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Active electron fluence risk declining. Risk of G1/Minor Storms throughout, mainly on 27 and 29 December. Slight chance of M-class flares.

Analysis of Space Weather Activity over past 24 hours
Solar Activity: Solar activity has been Low over the last 24 hours, with much of the activity from AR3176, a rapidly evolving and increasingly complex sunspot close to the eastern limb. The maximum flare from this region was a C6.0 at 26/1951UTC. There are five further regions on the disc, including the large and visually dominant regions of AR3169 and AR3171 in the northwest quadrant, with both appearing to be simplifying. The remaining regions all appear relatively benign. Two CMEs have been analysed in the last 24 hours, one from the southeast quadrant late on 25 December which appears to be directed away from Earth. A further eruption in the northwest quadrant during 26 December is currently being modelled with a risk of an Earth-directed component.

Solar Wind / Geomagnetic Activity: Solar wind speeds have followed a generally declining trend from 550km/s to 500km/s, but with a brief spike between 26/0700UTC and 26/0900UTC, peaking at 722km/s at 0737UTC, accompanied with an increase in density to around 20ppcc. Density was otherwise around average. Total magnetic field strength was moderate until around 26/530UTC when it fell to weak levels, but peaked at 11nT at 26/1015UTC. The north-south component, Bz, became moderately, but persistently negative between 26/0700UTC and 26/1530UTC, but has since varied between moderate positive and weak negative values. Phi angle was mainly positive, but became indeterminate between around 26/0900UTC and 26/1400UTC. Geomagnetic activity started Quiet to Unsettled, but became Active, then reached G1/Minor storm levels between 26/1200-1500UTC, before declining to Quiet levels. Analysis of data suggests that the Earth was subject to a weak CME passage during the periods indicated by spikes in the data.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 remained at Background levels.

High energy electron flux (greater than 2 MeV), started at high levels, peaking at 4.55e3 pfu at 26/0915UTC. This then sharply declined to background levels by 26/1500UTC in the presence of the effects of the suspected CME. Despite a brief jump to high levels, values have continue to decline to moderate counts by the end of the period, on a declining trend. Electron fluence has followed a declining trend and reached 7.06e7 integrated pfu at 25/2359UTC.

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Met Office Space Weather Technical Forecast

Four-Day Space Weather Forecast Summary
Solar Activity: Solar activity is forecast to be at mainly Low levels, but with an increasing risk of moderate activity from sunspots on, or rotating onto the eastern limb.

Solar Wind / Geomagnetic Activity: A CME which left the Sun early 24 December may have affected Earth on 26 December. Two further CMEs may affect the Earth over the next four days. The first, from an eruption on the 24 December, may arrive on 27 December, with one from the 25 December arriving on 29 December.

Coronal hole 57 is weakening and may not affect the Earth, or any effects may have been masked by the probable CME arrival. A further high speed stream from coronal hole 59 is forecast to connect to Earth on 29 December with speeds of 500-600km/s likely.

Geomagnetic activity is forecast to be mainly Unsettled on 27 December, with a risk of Active to G1/Minor Storm intervals. Generally Quiet to Unsettled on 28 December, but with a risk of elevated geomagnetic activity due to a possible early connection to coronal hole 59, with this considered more likely on 29 December, where there is a chance of Active to G1/Minor Storms. The forecast is currently uncertain for 30 December, with a recent fast CME which left the Sun late on 26 December from the northwest quadrant potentially being added to the forecast once analysis is complete.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels throughout, with a daily slight chance of reaching S1 levels.

High energy electron flux (greater than 2MeV) forecast is low confidence with the current downward trend likely to be part of the natural diurnal variation. Forecast geomagnetic activity and high speed streams are considered likely to suppress electron flux values through the next three days, with any recovery most likely on 30 December. There is a chance of electron fluence values reaching the Active threshold, but with limited confidence.

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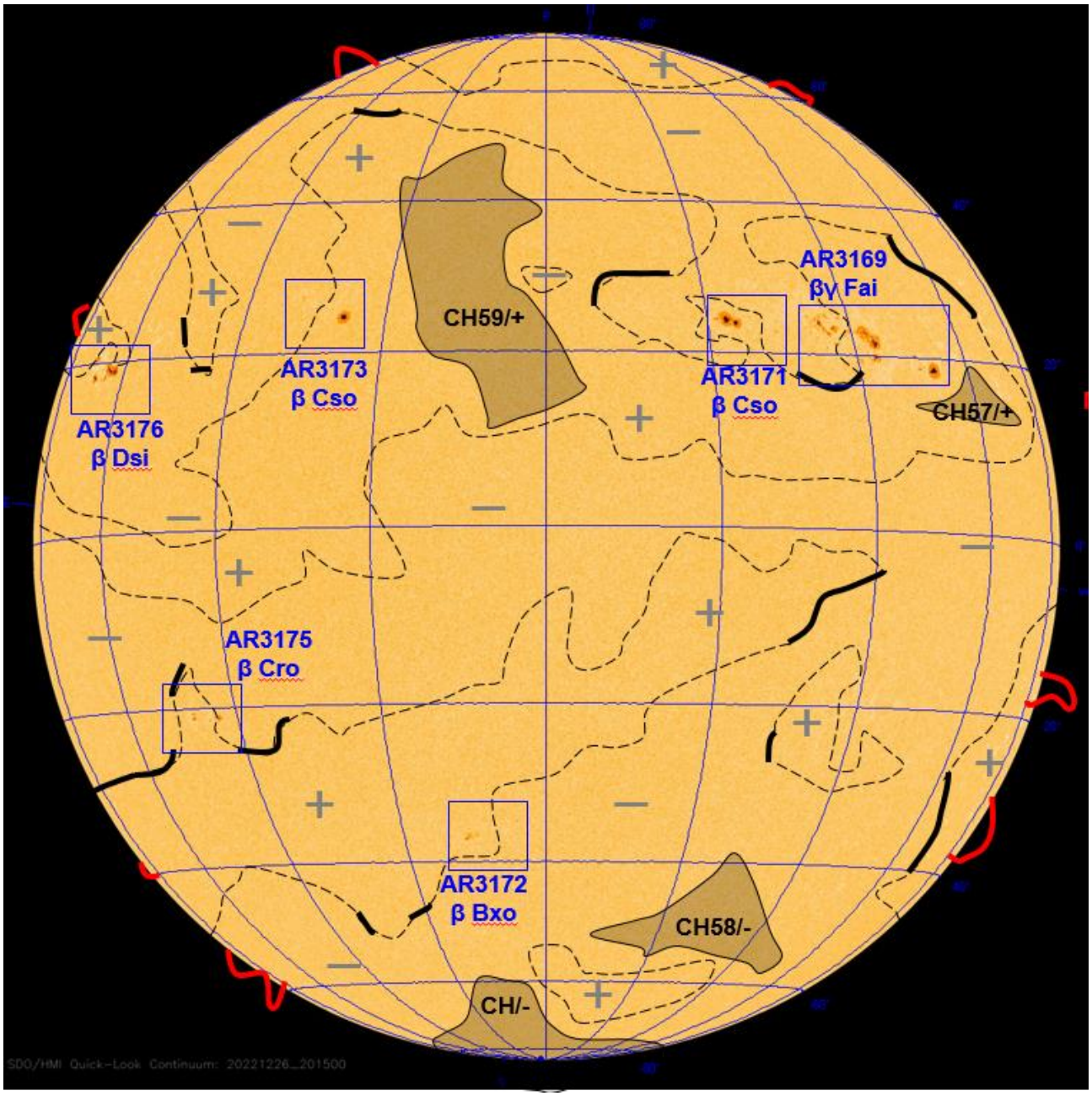
Figure 1. Solar Analysis Valid 25/2000UTC.



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Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are three CMEs which may feature in the forecast period. The first from an eruption at 24/0230UTC may have already glanced the Earth during 26 December, but is retained in the forecast for early 27 December, as any CME signature was inconclusive in available data. A CME which left the Sun 24/0800UTC may then arrive during 27 December. A final CME which left the Sun on 25 December for this forecast period may affect the Earth, most probably as a glancing blow on 29 December.

The Earth may also have been affected by the high speed stream from coronal hole 57. As this was a weakening feature any effects may have been masked by any possible CME arrival indicated above. The large coronal hole 59 may then connect with the Earth either late on 28 or during 29 December, based on a potential high speed stream of between 500-600km/s.

Geomagnetic activity is forecast to be mainly Unsettled on 27 December, with a risk of Active to G1/Minor Storm intervals in the presence of any CME arrivals. Generally Quiet to Unsettled on 28 December, based on forecast CME arrival times, but with a risk of elevated geomagnetic activity due to a possible early connection to coronal hole 59, with this considered more likely on 29 December, where there is a chance of Active to G1/Minor Storms. The forecast is currently uncertain for 30 December, with a recent fast CME which left the Sun late on 26 December from the northwest quadrant potentially being added to the forecast once analysis is complete.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	50	20	30	20
Strong	G3	No	5	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
24/0545UTC	Partial	Filament	NE quadrant	1100km/s	26/1600UTC	May have already arrived
24/1415UTC	Partial	Potentially AR3169	NE quadrant	620km/s	27 December	Low confidence
25/1245UTC	Partial	Near AR3168	SW quadrant	525km/s	29 December	Low confidence

Figure 2: 24 hours L1 solar wind data

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Radio Blackouts - X-Ray Flares:

Solar activity is expected to be mainly Low through the next four days, with none of the mature regions on the visible disc of the Sun exhibiting significant activity. The most active region is now the rapidly developing, but difficult to analyse AR3176 close to the northeast limb. This has been responsible for a number of C-class flares since rotating onto the disc and continue to evolve in complexity. The production of a number of CMEs just beyond the eastern limb and the observation of far sided bright flux regions suggest a trend for more complex regions to rotate onto the disc. A slight increase in the risk of M-class flares is then forecast through the next four days.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	30	40	40	40
Very Active	R3 to R5 X Class	No	1	1	1	1

Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) is expected to remain at Background levels. Forecast probabilities remain at a slight chance due to the possibility of any larger flares perhaps fromAR3169, although this spot seems to have developed a tendency to discharge its energy regularly and at low levels, with no evidence as yet of any proton enhancements. AR3176, which is rapidly evolving in complexity, may also demonstrate a risk of M-class flares through the next four days.

Radiation Storms	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	No	5	5	5	5
Very Active	≥ S3 *	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

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High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) has been following a declining trend through the last six hours, having previously been at high levels prior to the recent geomagnetic storming. This is likely to be part of diurnal variation, exacerbated by the recent G1/Minor Storms. This trend of moderate to high (1e3 pfu) levels of electron flux are likely during 27 and 28 December in the absence of significant geomagnetic activity, which could distort the belts and redistribute electrons away from the radiation belts. The likely onset of a high speed stream from coronal hole 59 on 29 December may initially distort the belts, leading to an observed reduction in electron counts at GEO, which may then continue through into 30 December, depending on the strength of the high speed stream.

Electron fluence is following a slight downward trend, with this expected to continue through 27 December in a more muted electron flux environment compared to the previous 24 hours. The remaining of the forecast period is subject to the caveats mentioned above, with the likelihood of increased geomagnetic activity and belt distortion biasing the forecast to a lower likelihood of exceeding the Active (1e8 integrated pfu) threshold through the next three days, with a slight increase then possible on 30 December.

GEO Electron Environment	Level ($cm^{-2}\ sr^{-1}\ day^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	50	20	20	30
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

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